Chapter 11

Magnesium Production

The primary magnesium processing industry, as discussed in this report, consists of one anhydrous electrolytic magnesium-producing facility that, as of September 1989, was active and reported generating a special waste from mineral processing: process wastewater from primary magnesium processing by the anhydrous process. Two other primary magnesium producing facilities are operating in the U.S. One uses electrolysis but employs, the hydrous process; the other uses a silicothermic process. Neither facility generates a special waste from mineral processing covered under the Mining Waste Exclusion; therefore, these two facilities, their operations, and the wastes that they generate are not addressed in this report. Information included in this chapter is discussed in additional detail in the supporting public docket for this report.

11.1 Industry Overview

The primary use of magnesium metal is as an alloying element in aluminum-base alloys; these alloys are used in the manufacture of such products as beverage cans and transportation equipment. Casting and extrusions of magnesium-base alloys are used in transportation equipment, power tools, computers, and sporting goods. Additional uses for magnesium metal are in the production of ferrous metal (e.g., iron and steel desulfurization, and production of nodular iron) and non-ferrous metal (used as a reducing agent).[1,2]

The anhydrous electrolytic magnesium production facility is located in Rowley, Utah, and is operated by the Magnesium Corporation of America (Magcorp). The facility initiated operations in 1972 and was modernized in 1976 and 1984. The annual production capacity of the facility is reportedly 36,500 metric tons. The total 1988 production of magnesium at the facility was 29,000 metric tons; therefore, the annual capacity utilization rate was 79.4 percent.[3]

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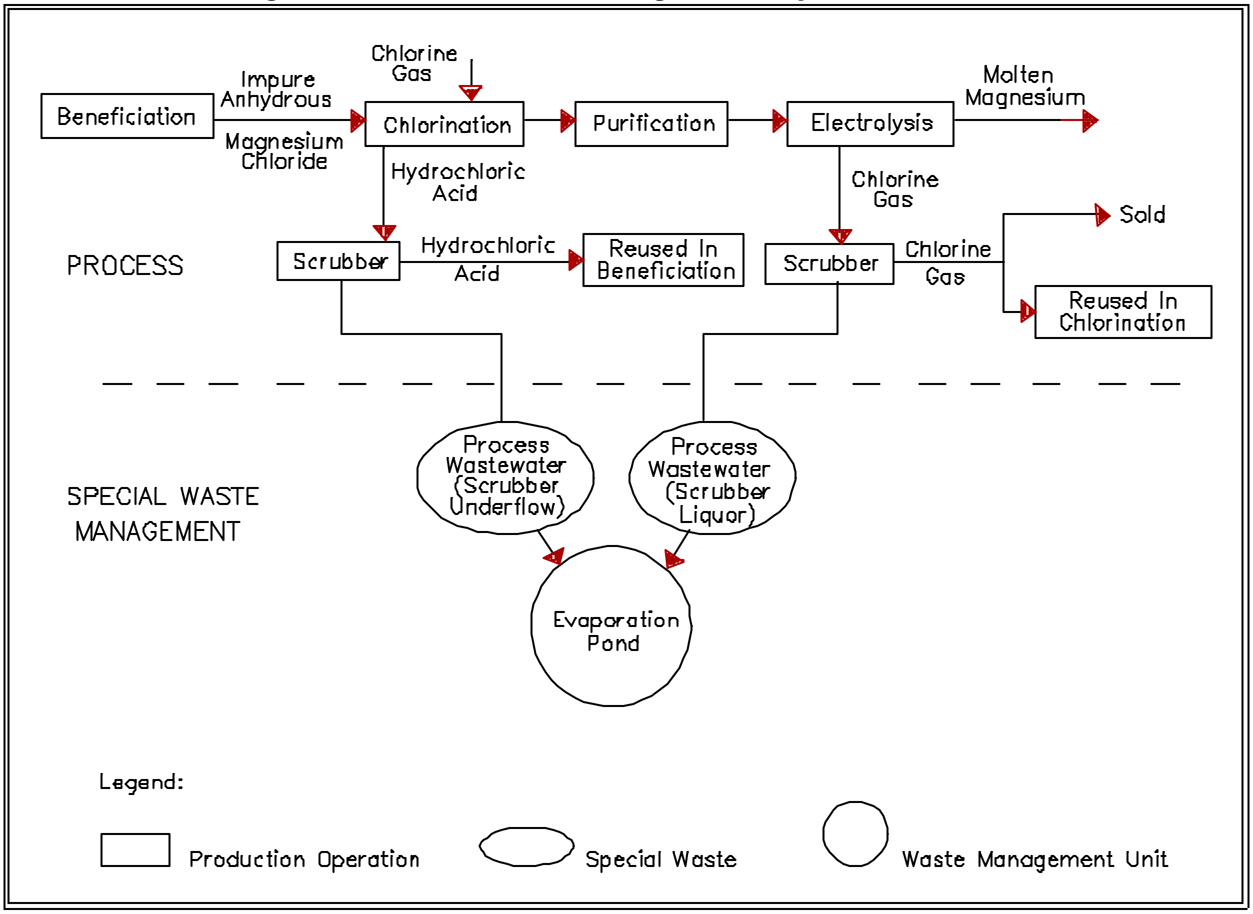
[1] Bureau of Mines, 1985. Mineral Facts and Problems, 1985 Ed.; p. 475.

[2] Bureau of Mines, 1987. Minerals Yearbook, 1987 Ed.; p. 588-9.

[3] Magcorp, 1989. Company Response to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA, 1989.

Exhibit 11-1
Magnesium Production Using the Anhydrous Process



No specific information was found regarding trends at the Utah facility, but, at 142,000 metric tons, 1988 U.S. production of primary magnesium was at its highest level since 1984. In 1989, the estimated U.S. primary production was 150,000 metric tons. Primary producers operated at nearly full capacity by year end 1989.[4] The primary magnesium industry in North America has expanded since 1988 as a new Canadian plant has come on-line[5] and as the Dow Chemical Company in Freeport, Texas has increased its production capacity.[6]

Consumption of primary magnesium has increased significantly since 1986 when it fell to 70,000 metric tons from a 1985 level of 76,000 metric tons. Reported consumption of primary magnesium for 1989 was estimated to be 105,000 metric tons. While the U.S. imports some magnesium for consumption, it remains a net exporter.[7]

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[4] Deborah A. Kramer, U.S. Bureau of Mines, "Magnesium Metal," Mineral Commodity Summaries, 1990 Ed., p. 102.

[5] *Ibid.*, p. 103.

[6] Deborah A. Kramer, U.S. Bureau of Mines, "Magnesium," Minerals Yearbook, 1988 Ed., p. 1.

[7] Kramer, op. cit., p. 102.

In the anhydrous process used at Rowley, impure anhydrous magnesium chloride powder, which is produced by beneficiation operations performed at the facility,[8] is purified and then magnesium is isolated using electrolysis, as shown in Exhibit 11-1.[9,10] The first purification step is chlorination, which is necessary because during the final beneficiation operation, spray drying, some magnesium oxide is generated that must be converted to magnesium chloride. In this step, the impure magnesium powder is melted in an induction/arc furnace and reacted with chlorine gas in a reaction cell to convert any magnesium oxide to the chloride salt. Hydrochloric acid formed during this chlorination step is sent to scrubbers; the cleaned acid is reused in the beneficiation operations (i.e., for sulfate removal). The scrubber underflow, one source of process wastewater, is disposed in an on-site impoundment. Purification of the magnesium chloride is completed by the addition of other reactants (e.g., ferric chloride, coke, sparge methane) to the molten salt to remove water, bromine, residual sulfate, and heavy metals.[11] A low volume solid (not a special waste from mineral processing), known as smut, is the only waste generated from this final purification operation.

After purification, molten magnesium chloride is separated into chlorine gas and molten magnesium by applying direct current to the material in electrolytic cells. The purified and separated magnesium metal is vacuumed from the surface of the electrolytic cell bath; the molten metal is then cast into shapes and alloyed in a casting plant.[12] The chlorine gas is removed, scrubbed, cooled, and reused or sold. Stack emissions of chlorine gas arising from this process are significant (approximately one million pounds annually); in fact, the Rowley facility is the nation's largest source of such emissions. The resulting scrubber liquor, which is the second source of process wastewater, is also disposed in the on-site impoundment, along with non-contact cooling water (not a special waste).

11.2 Waste Characteristics, Generation, and Current Management Practices[13]

Approximately 2,465,000 metric tons of process wastewater reportedly were generated by the Rowley facility in 1988.[14] This wastewater contains approximately 2.2 percent solids, consisting predominantly of chlorides, magnesium, sulfate, sodium, calcium, and other metals in trace amounts.

As noted above, the process wastewater is disposed in an on-site impoundment. This impoundment is 1.2 meters (4 feet) deep, has a surface area of about 160 hectares (400 acres), and a volume of nearly 2 million cubic meters. In this impoundment, referred to by the company as the NPDES waste pond, the pH of the process wastewater is reportedly adjusted, though no reagents are added.[15] Solar evaporation and infiltration into the ground are used to reduce the wastewater quantity. There is no discharge to surface water of wastewater from the pond, and no sludge is removed. Process water does not, however, accumulate, nor do any significant volumes of solids settle out of the water in the pond, according to the company.

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[8] The beneficiation steps include: concentration of salt brine solution; precipitation of potassium; treatment with calcium chloride for partial removal of sulfates; and removal of boron by phase separation (i.e., solvent extraction) using isooctanol in a kerosene carrier. Upon removal of sulfate and boron from the brine, water is evaporated at 600 degrees centigrade, producing an impure anhydrous magnesium chloride powder.

[9] Environmental Protection Agency, 1984. Overview of Solid Waste Generation, Management, and Chemical Characteristics: Primary Antimony, Magnesium, Tin, and Titanium Smelting and Refining Industries. Prepared by PEI Associates for U.S. EPA, Office of Solid Waste, Washington, D.C., 1984.

[10] Marks, 1978. Encyclopedia of Chemical Technology, Marks, et al., editors; Wiley Interscience, New York, NY, 1978; p. 581.

[11] Marks, op. cit., p. 581.

[12] Environmental Protection Agency, 1984. Overview of Solid Waste Generation, Management, and Chemical Characteristics: Primary Antimony, Magnesium, Tin, and Titanium Smelting and Refining Industries. Prepared by PEI Associates for U.S. EPA, Office of Solid Waste, Washington, D.C., 1984.

[13] Information provided in this section, unless otherwise noted, is from the response of Amax Magnesium Co. to EPA's "National Survey of Solid Wastes from Mineral Processing Facilities," conducted in 1989.

[14] The corresponding waste-to-product ratio (i.e., metric ton of process wastewater to metric ton of magnesium) was 85.

[15] In comments addressing the October 20, 1988 NPRM (53 FR 41288) (Docket No. -- MWEP 00018), AMAX indicated that the oolitic sand, calcium carbonate, provides "a neutralization media for the acidic wastewater."

The impoundment is also used for disposal of several other aqueous wastewaters that are not special wastes from mineral processing operations (e.g., calcium sulfate repulp liquor, calcium chloride thickener underflow, and additional beneficiation wastewaters) and non-contact cooling waters; the latter stream was generated at a volume of approximately 1,060,000 metric tons in 1988.[16]

Using available data on the composition of magnesium process wastewater, EPA evaluated whether the wastewater exhibits any of the four characteristics of hazardous waste: corrosivity, reactivity, ignitability, and extraction procedure (EP) toxicity. Based on available information and professional judgment, the Agency does not believe the wastewater is reactive, ignitable, or EP toxic. In fact, all eight inorganic constituents with EP toxicity regulatory levels, with the exception of selenium, are present in concentrations that are at least two orders of magnitude below the regulatory level, that is, below drinking water standards; selenium was not detected in the wastewater. Some wastewater samples, however, exhibit the characteristic of corrosivity. A pH of approximately 1.2, which is below the lower bound corrosivity limit of 2.0, was measured in two out of two samples of magnesium process wastewater at the Magcorp facility. The Rowley facility also reports that the wastewater has an average pH of 1.6.

11.3 Potential and Documented Danger To Human Health and The Environment

This section addresses two of the study factors required by §8002(p) of RCRA: (1) potential danger (i.e., risk) to human health and the environment; and (2) documented cases in which danger to human health or the environment has been proved. Overall conclusions about the hazards associated with magnesium process wastewater are provided after these two study factors are discussed.

11.3.1 Risks Associated With Magnesium Process Wastewater

Any potential danger to human health and the environment from magnesium process wastewater is a function primarily of the composition of the wastewater, the practices that are employed to manage it, and the environmental setting of the facility where the wastewater is generated and managed. These factors are discussed separately below.

Constituents of Potential Concern

EPA identified chemical constituents in the magnesium process wastewater that may present a hazard, by collecting data on the composition of wastewater from the Magcorp facility in Rowley and evaluating the intrinsic hazard of the chemical constituents present in the wastewater.

Data on Magnesium Process Wastewater Composition

EPA's characterization of magnesium process wastewater is based on data from a 1989 sampling and analysis effort by EPA's Office of Solid Waste (OSW). These data provide information on the concentrations of 20 metals and sulfate in total analyses and EP and SPLP leach test analyses; the concentrations of constituents measured in these three types of analyses are generally consistent.

Process for Identifying Constituents of Potential Concern

As discussed in detail in Section 2.2.2, the Agency evaluated the available data to determine if magnesium process wastewater or leachate from this waste contain any chemical constituents that could pose an intrinsic hazard, and to narrow the focus of the risk assessment. The Agency performed this evaluation by first comparing constituent concentrations to screening criteria and then by evaluating the environmental persistence and mobility of constituents that are present at levels above the criteria. These screening criteria were developed using assumed scenarios that are likely to overestimate the extent to which the process wastewater constituents are released to the environment and

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[16] In comments addressing the October 20, 1988 NPRM (53 FR 41288) and found in the docket (Docket No. -- MWEP 00018), AMAX indicated that non-contact cooling water is generated in quantities equalling 43 percent of the quantity of the process wastewater.

Exhibit 11-2
Potential Constituents of Concern In Magnesium Process Wastewater[a]

Potential Constituents of Concern	Number of Times Constituent Dectected/ Number of Analyses for Constituent	Screening Criterion	Number of Analyses Exceeding Criteria/ Number of Analyses for Constituent
Iron	2 / 2	Resource Damage	2 / 2
Molybdenum	2 / 2	Resource Damage	2 / 2
Copper	2 / 2	Aquatic Ecological	1 / 2
Aluminum	2 / 2	Aquatic Ecological	1 / 2
Manganese	1 / 2	Resource Damage	1 / 2
pH	2 / 2	Resource Damage	2 / 2

[a] Constituents listed in this table are present in the sample from the facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample.

migrate to possible exposure points. As a result, this process identifies and eliminates from further consideration those constituents that clearly do not pose a risk.

The Agency used three categories of screening criteria that reflect the potential for hazards to human health, aquatic ecosystems, and air and surface/ground-water resources (see Exhibit 2-3). Given the conservative (i.e., overly protective) nature of these screening criteria, contaminant concentrations in excess of the criteria should not, in isolation, be interpreted as proof of hazard. Instead, exceedances of the criteria indicate the need to evaluate the potential hazards of the waste in greater detail.

Identified Constituents of Potential Concern

Exhibit 11-2 presents the results of the comparisons for process wastewater analyses to the screening criteria described above. This exhibit lists all constituents for which the measured concentration exceeds a screening criterion.

Of the 21 constituents analyzed in the process wastewater, only iron, molybdenum, copper, aluminum, and manganese concentrations, as well as pH levels, exceed the screening criteria. Among these constituents, iron, molybdenum, and pH exceed the screening criteria with the greatest frequency and magnitude. For example, only iron and molybdenum exceed the screening criteria by a factor of 10 or more. No constituents, however, were detected in concentrations that exceed the EP toxicity regulatory level, though the pH is low enough for the waste to exhibit the hazardous waste characteristic of corrosivity. These concentrations indicate the potential for different types of impacts caused by wastewater seepage:

- If the wastewater is released to ground or surface water and diluted by a factor of 10 or less, iron, molybdenum, and manganese concentrations may be sufficiently high to render the affected ground or surface waters unsuitable for a variety of uses (e.g., direct human consumption, irrigation, livestock watering). The resulting pH levels could also be corrosive.
- Copper and aluminum are present in the wastewater at concentrations that, if released to surface water and diluted by a factor of 100 or less, could exceed criteria for the protection of aquatic life.

These exceedances, by themselves, do not prove that the wastewater poses a significant risk, but indicate that the wastewater may present a hazard under a hypothetical set of release, transport, and exposure conditions. To determine the potential for this waste to cause significant impacts, EPA proceeded to the next step of the risk assessment and analyzed the actual conditions that exist at the facility that generates and manages the wastewater.

Release, Transport, and Exposure Potential

This analysis evaluates the baseline hazards of magnesium process wastewater as it was generated and managed at the Magcorp facility in 1988. It does not assess the hazards of off-site use or disposal of the wastewater because this waste is not currently used or disposed off-site, and off-site management or use is not likely in the future. The following analysis also does not consider the risks associated with variations in waste management practices or potentially exposed populations in the future because of a lack of data on which to base projections of future conditions.

Ground-Water Release, Transport, and Exposure Potential

The waste composition data discussed above indicate that several constituents contained in the magnesium process wastewater (i.e., iron, molybdenum, copper, aluminum, and manganese) are present in concentrations above the screening criteria. However, depending on the pH of the seepage and the receiving aquifer, some of the constituents may not be mobile in ground water. Molybdenum is the only constituent that exceeds the screening criteria that is relatively mobile in ground water under neutral pH conditions. While the pH of the process wastewater in the waste pond is very low (less than 2), it is expected to be neutralized to some extent as the wastewater seeps through the oolitic sand (calcium carbonate) underlying the pond. Nevertheless, the neutralization capacity of the oolitic sand is finite, and in time, acidic seepage could potentially migrate to ground water. Although the ground water does not appear to be acidic at this time,[17] the continued seepage of the acidic wastewater could lower the pH to below 5, and iron, copper, and manganese could also become relatively mobile in the aquifer. Aluminum is relatively immobile in ground water under both neutral and low-pH conditions.

Ground water beneath the Magcorp facility occurs in shallow permeable strata that contain salt waters intruding from the Great Salt Lake and in a deeper aquifer (located 60 meters below the land surface) that is used as a source of livestock water. This deeper aquifer is also saline. The standing quantity of process wastewater in the pond (which is more than 1 meter deep) provides sufficient hydraulic head to drive liquids from the impoundment into the shallow ground water that underlies the facility. Releases to this shallow ground water are not limited by engineered controls such as a liner or leachate collection system, and in fact, infiltration into the ground is purposefully used by the facility and controlled by the State as a way to reduce water volumes. The impoundment, however, is underlain by oolitic sand, which the facility claims neutralizes any wastewater that leaches from the impoundment, and by in-situ clay.

Under these conditions, process wastewater slowly seeps into the shallow ground water beneath the impoundment. The Utah Bureau of Water Pollution Control stated in the NPDES permit for this facility that data presented by Magcorp indicate that seepage from the impoundment has occurred, but that it "was of low volume and did not pose a significant environmental or human health threat."[18] Releases to the deep aquifer are restricted by a fairly continuous clay confining layer, according to local researchers with the U.S. Geological Survey. Therefore, seepage of process wastewater from the impoundment could contaminate the ground water that is hydraulically connected to the Great Salt Lake, but is unlikely to adversely affect the 60-meter deep aquifer that is used for livestock water.

[17] As a condition of the company's NPDES permit, Magcorp is required to monitor ground water quarterly and report any pH excursions outside the range of 6.5 to 9.0. To the best of EPA's knowledge, no excursions have been reported as of this writing.

[18] Utah Division of Environmental Health (DEH), Bureau of Water Pollution Control, 1989. Statement of Basis for Utah Pollutant Discharge Elimination System Permit No. UT0000779.

Surface Water Release, Transport, and Exposure Potential

Magnesium process wastewater could enter surface waters by seeping through shallow ground water that is hydraulically connected with the Great Salt Lake (as discussed above), or by direct overland run-off of process wastewater in the event that the impoundment is overtopped or its berms fail. Direct discharges from the impoundment to the lake are prohibited by the NPDES permit for the facility. As discussed above, iron and molybdenum, and to a lesser extent, copper, aluminum, and manganese could pose human health or aquatic ecological threats if discharged to typical receiving waters. The Great Salt Lake is not a typical receiving water, however -- there is no drinking water pathway for human exposure, and it is not clear whether the biota in the Great Salt Lake are more tolerant or less tolerant, compared to most fresh-water species, to elevated concentrations of these metals.

Overland run-off of process wastewater to the Great Salt Lake due to overflow from the impoundment, resulting from excessive precipitation or berm failure, is limited by storm water run-on/run-off controls at the unit, the low precipitation in the area (36 cm/year), and relatively small maximum snow accumulation (26 cm). Furthermore, inundation of the wastewater pond by waters from the Great Salt Lake is unlikely because the pond berms have been raised (up to 10 meters) to safeguard against this possibility.[19] Nevertheless, contaminants from the process wastewater could migrate to the lake by discharge of ground water from the shallow aquifer. Because the lake water is not used for consumptive purposes, surface water releases pose no health threats from drinking water exposures, though recreational use of the lake could potentially pose health threats. Aquatic life (i.e., brine shrimp) also may be adversely affected by any releases of magnesium process wastewater to the lake.

Air Release, Transport, and Exposure Potential

Because all of the constituents of potential concern are non-volatile, magnesium process wastewater contaminants can only be released to air in the form of wind-blown particles (dust). The physical form of the wastewater essentially precludes any particle releases to air. In principle, dry deposits could be formed at the edges of the pond when the process wastewater is evaporated to reduce its volume, and dust releases from these deposits at the rim of the impoundment could occur (i.e., particles could be blown into the air by wind). However, the potential for significant airborne release and exposure is expected to be negligible because the area of dry salt deposits is expected to be relatively small as long as the impoundment is active. After closure, however, there may be dusting if the impoundment is dried and the remaining residue is not covered.

Proximity to Sensitive Environments

Other than the Great Salt Lake, which is used for recreational purposes, the Magcorp facility is not located in or near environments that are especially vulnerable to contaminants or that have high resource value (e.g., wetlands, endangered species habitats) that may warrant special consideration.

Risk Modeling

Based upon the evaluation of intrinsic hazard and the descriptive analysis of factors that influence risk presented above, and upon a review of information available on documented damage cases (presented in the next section), EPA has tentatively concluded that the potential for process wastewater from primary magnesium production by the anhydrous process to impose significant risk to human health or the environment if managed according to current practice is low. This conclusion is supported by low risk estimates developed from the Agency's modeling of other mineral processing wastes that appear to pose a greater hazard than magnesium process wastewater. Therefore, the Agency has not conducted a quantitative risk modeling exercise for this waste. (See sections 11.3.3 and 11.7 below for further discussion.)

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[19] The pond currently in use was located on high terrain and constructed with large berms because impoundments used in the past that were closer to the lake were flooded due to high lake levels and storm conditions.

11.3.2 Damage Cases

State files were reviewed in an effort to document the performance of waste management practices for process wastewater from primary magnesium processing by the anhydrous process for Magcorp's facility in Tooele County, Utah. The file reviews were combined with interviews with State regulatory staff. EPA found no documented environmental damages associated with process wastewater management units at this facility. Nonetheless, as noted above, a study performed by the facility indicates that seepage from the impoundment does occur, but the Utah Division of Environmental Health, Bureau of Water Pollution Control has concluded that "the seepage was low volume and that it didn't pose any real human health or significant environmental threat."[20] In addition, releases from previous impoundments to the Great Salt Lake have occurred in the past when the impoundments have been flooded by the lake due to high lake levels and storm conditions, but the impacts of the releases have not been documented.

11.3.3 Findings Concerning the Hazards of Magnesium Process Wastewater

The available data indicate that wastewater is being released from the impoundment used for wastewater disposal at the Rowley facility, but the potential danger to human health or the environment, if any, is low due to the location of the impoundment and the characteristics of the wastewater. Specifically, releases to the deep, useable aquifer are restricted by a fairly continuous clay confining layer. Only a few contaminants exceeded the screening criteria and releases from the impoundment to the Great Salt Lake via ground water or overland flow are unlikely to result in harmful concentrations in the Lake. In addition, the pH of the seepage is being monitored under the conditions of a State permit (see below) that also requires seepage to be prevented if the required monitoring indicates the pH is outside of the acceptable range (6.5 to 9).

Although the wastewater is corrosive, the low concentrations of toxic constituents, the evaluation of the release, transport, and exposure pathways, and the absence of any documented cases of danger to human health or the environment, lead EPA to tentatively conclude that the hazard posed by process wastewater from primary magnesium production by the anhydrous process as currently managed is relatively low. As a result, only limited discussions of alternative management practices, utilization, and costs and impacts are provided below. The discussion of costs includes the potential costs of regulation under Subtitle C of RCRA because the waste does exhibit the hazardous waste characteristic of corrosivity.

11.4 Existing Federal and State Waste Management Controls

11.4.1 Federal Regulation

Under the Clean Water Act, EPA has the responsibility for setting "effluent limitations," based on the performance capability of treatment technologies. These "technology based limitations," which provide the basis for minimum requirements of NPDES permits, must be established for various classes of industrial discharges, including a number of ore processing categories.

Permits for mineral processing facilities may require compliance with effluent guidelines based on best practicable control technology currently available (BPT) or best available technology economically achievable (BAT). BPT and BAT requirements for magnesium production specify that there shall be no discharge of process wastewater pollutants to navigable waters (40 CFR 436.120).

EPA is unaware of any other federal management control or pollutant release requirements that apply specifically to this wastewater stream.

[20] Utah DEH, 1989, op. cit.

11.4.2 State Regulation

The single primary magnesium processing facility currently active in the United States and addressed by this report is located in Rowley, Utah. The State of Utah excludes the process wastewater generated by this facility from both hazardous and solid waste regulation. Utah does have an approved NPDES program, however, and requires that the Rowley facility maintain a no discharge permit for its process wastewater surface impoundment. Under the terms of this permit, the facility owner/operator must monitor pH both in ground water and any standing surface water adjacent to the impoundment, and if pH levels are outside of the range of 6.5 to 9.0, notify the state and EPA immediately. The state is aware that some seepage from the surface impoundment may be occurring, but has concluded that the seepage has not caused adverse environmental affects. Utah recently enacted new ground-water protection legislation that might address the process wastewater managed at the Rowley facility, though the state has not yet issued any permits.

11.5 Waste Management Alternatives and Potential Utilization

Wastewater management alternatives are generally limited in scope to strategies for recycling, treating, and/or disposing of the material. In the case of process wastewater from primary magnesium production, EPA believes that management alternatives consist primarily of treating the wastewater (i.e., pH adjustment), and either discharging the treated effluent to the existing evaporation impoundment or recycling it to the magnesium production operation. Sludge generation as a result of such treatment would depend on the pH of the treated wastewater and the treatment agent(s) employed. If sludge is generated by this management scheme, it might require disposal in a RCRA Subtitle C facility (due to heavy metal content). The costs associated with this waste management alternative are examined below in section 11.6.

11.6 Cost and Economic Impacts

Section 8002(p) of RCRA directs EPA to examine the costs of alternative practices for the management of the special wastes considered in this report. EPA has responded to this requirement by evaluating the operational changes that would be implied by compliance with three different regulatory scenarios, as described in Chapter 2. In reviewing and evaluating the Agency's estimates of the cost and economic impacts associated with these changes, it is important to remember what the regulatory scenarios imply, and what assumptions have been made in conducting the analysis.

The focus of the Subtitle C compliance scenario is on the costs of constructing and operating hazardous waste management units. Other important aspects of the Subtitle C system (e.g., corrective action, prospective land disposal restrictions) have not been explicitly factored into the cost analysis. Therefore, differences between the costs estimated for Subtitle C compliance and those under other scenarios (particularly Subtitle C-Minus) are less than they might be under an alternative set of conditions (e.g., if most affected facilities were not already subject to Subtitle C, if land disposal restrictions had been promulgated for "newly identified" hazardous wastes). The Subtitle C-Minus scenario represents, as discussed above in Chapter 2, the minimum requirements that would apply to any of the special wastes that are ultimately regulated as hazardous wastes; this scenario does not reflect any actual determinations or preliminary judgments concerning the specific requirements that would apply to any such wastes. Further, the Subtitle D-Plus scenario represents one of many possible approaches to a Subtitle D program for special mineral processing wastes, and has been included in this report only for illustrative purposes. The cost estimates provided below for the three scenarios considered in this report must be interpreted accordingly.

In accordance with the spirit of RCRA §8002(p), EPA has focused its analysis on impacts on the firms and facilities generating the special wastes, rather than on net impacts to society in the aggregate. Therefore, the cost analysis has been conducted on an after-tax basis, using a discount rate based on a previously developed estimate of the weighted average cost of capital to U.S. industrial firms (9.49 percent), as discussed in Chapter 2. Waste generation rate estimates (which are directly proportional to costs) for the period of analysis (the present through 1995) have been developed in consultation with the U.S Bureau of Mines.

In this section, EPA first outlines the way in which it has identified and evaluated the waste management practices that would be employed under different regulatory scenarios by Magcorp's primary magnesium production facility in Rowley, Utah. Next, the section discusses the cost implications of requiring these changes to existing waste management practices. The last part of the section predicts and discusses the ultimate impacts of any increased waste management costs faced by the facility.

11.6.1 Regulatory Scenarios and Required Management Practices

Based upon the information presented above, EPA believes that process wastewater from the Rowley facility poses a low degree of hazard; the waste does, however, exhibit the hazardous characteristic of corrosivity, based on EPA and industry sampling data. Accordingly, the Agency has estimated the costs associated with regulation under Subtitle C of RCRA, as well as with two somewhat less stringent regulatory scenarios, referred to here as "Subtitle C-Minus" and "Subtitle D" (a more detailed description of the cost impact analysis and the development of these regulatory scenarios is presented in Chapter 2, above). In the following paragraphs, EPA discusses the assumed management practices that would occur under each regulatory alternative.

Subtitle C

Under Subtitle C standards, hazardous waste that is managed on-site must meet the rigorous standards codified at 40 CFR Part 264 for hazardous waste treatment, storage, and disposal facilities. Because magnesium anhydrous process wastewater is a dilute, aqueous liquid that is corrosive but not EP toxic, the management practice of choice under Subtitle C is treatment (neutralization) in a tank. EPA has determined that within the relevant size range, tank treatment is the least-cost management method, and has conducted its analysis accordingly. The scenario examined here involves construction of a Subtitle C surge pond (double-lined surface impoundment), and a tank treatment system. Following neutralization, the treated process wastewater may be reused by the facility or discharged to the existing surface impoundment, just as it is under current practice. The treatment sludge, which is assumed to not be a hazardous waste, is disposed in an unlined disposal impoundment/landfill.

Subtitle C-Minus

Assumed practices under Subtitle C-Minus are identical to those described above for the full Subtitle C scenario, with the exception that some of the strict requirements for construction and operation of the hazardous waste surge pond have been relaxed, most notably the liner design requirements. Because other Subtitle C provisions apply in full, there are no significant operational differences between the two scenarios.

Subtitle D-Plus

Assumed practices under Subtitle D-Plus are identical to those described above for the full Subtitle C scenario, with the exception that, as under Subtitle C-minus, some of the strict requirements for construction and operation of the hazardous waste surge pond have been relaxed, most notably the liner design requirements. Because other provisions that are analogous to Subtitle C controls apply under this scenario, there are no significant operational differences between this and the other two scenarios.

11.6.2 Cost Impact Assessment Results

Results of the cost impact analysis for the magnesium anhydrous processing sector are presented by regulatory scenario in Exhibit 11-3

. Under the Subtitle C scenario, annualized incremental regulatory compliance costs are estimated for Magcorp's Rowley facility to be $1.23 million greater than baseline (over 4 times the baseline costs). Annualized incremental capital compliance expenditures are estimated at $286,000, or approximately 23 percent of the total incremental compliance costs.

Under the somewhat less rigorous requirements of the Subtitle C-Minus scenario, costs of regulatory compliance are lower, due to decreased capital construction outlays. Magcorp's annualized compliance costs under this scenario are estimated to be $1.18 million greater than baseline (about 4 times baseline costs). The total compliance cost for the sector is only about three percent less than under the full Subtitle C scenario. The primary reason for the difference in waste management costs is the configuration of the surge pond liner system; under the Subtitle C-Minus scenario, disposal units are equipped with a single synthetic liner and leachate collection system, rather than the dual system required under full Subtitle C regulation.

Costs under the Subtitle D-Plus regulatory scenario are identical to those under Subtitle C-Minus scenario. The configuration of the surge pond, the only varying factor between Subtitle C and C-minus, is the same for D-Plus and C-Minus (installation of a composite liner with clean closure).

11.6.3 Financial and Economic Impact Assessment

To evaluate the ability of the affected facility to bear these regulatory compliance costs, EPA conducted an impact assessment consisting of three steps. First, to assess the magnitude of the financial burden that would be imposed in the absence of changes in magnesium supply, demand, or price, the Agency calculated financial impact ratios by comparing the estimated compliance costs to several measures of the financial strength of the facility. Next, in order to determine whether compliance costs could be distributed to (shared among) other production input and product markets, EPA conducted a qualitative evaluation of the salient market factors that affect the competitive position of domestic primary magnesium producers. Finally, the Agency combined the results of the first two steps to arrive at predicted ultimate compliance-related economic impacts on the facility. The methods and assumptions used to conduct this analysis are described in Chapter 2 and in Appendices E-3 and E-4 (in Volume III) to this report.

Financial Ratio Analysis

EPA's ratio analysis indicates that regulation under any of the three scenarios would impose marginally significant impacts on the one affected facility. The costs associated with management of process wastewater under Subtitle C represent around one percent of value added (which in this case is the equal to value of shipments), as shown in Exhibit 11-4. The only potentially significant impact is that of the required annualized compliance capital as a percentage of current total annual sustaining capital investments; additional capital above and beyond sustaining capital would be required to cover increased capital needs. The values of this ratio are somewhat deceptive, however, since capital compliance costs are relatively low in magnitude ($250,000 to $286,000 annually). The results of the ratio analysis are high because sustaining capital, the denominator in the ratio analysis, is relatively small because the plant and equipment used in the anhydrous process do not require high levels of continual capital investments.

Market Factor Analysis

General Competitive Position

The United States imports little magnesium metal, most of it coming from Norway and Canada, and is a net exporter of the metal. There are three companies producing magnesium metal in the United States. Magcorp recovers magnesium from Great Salt Lake brines in Utah; Dow from seawater in Texas; and Northwest Alloys from dolomite in Washington state. Domestic production of magnesium metal increased in 1988, with some facilities running at 100 percent of capacity. Production of magnesium metal from primary processing facilities totaled 156,500 short tons in 1988 and overall, producers operated at 91 percent of the industry's rated capacity. The estimated capacity for the sector will increase from 172,000 short tons in 1988 to 181,000 short tons in 1989. In addition, nearly 50,000 tons of raw and old scrap were recovered. These trends are related to recent increases in U.S. demand for magnesium, which have also led to price increases and temporary shortages.

Exhibit 11-4
Significance of Regulatory Compliance Costs for Mangement of Process Wastewater from Primary Magnesium Processing by the Anhydrous Process[a]

Facility	CC/VOS	CC/VA	IR/K
Subtitle C			
Magcorp - Rowley, UT	1.3%	1.3%	9.5%
Subtitle C-Minus			
Magcorp - Rowley, UT	1.2%	1.2%	8.2%
Subtitle D-Plus			
Magcorp - Rowley, UT	1.2%	1.2%	8.2%

CC/VOS = Compliance Costs as Percent of Sales
CC/VA = Compliance Costs as Percent of Value Added
IR/K = Annualized Capital Investment Requirements as Percent of Current Capital Outlays
(a) Values reported in this table are based upon EPA's compliance cost estimates. The Agency believes that these values are precise to two significant figures.

Potential for Compliance Cost Pass-Through

Labor Markets. Approximately 450 people were employed in the U.S. in the primary production of magnesium metal, though the number employed at Rowley is not known. The average salary was $26,652 per year. It is unlikely that there could be reductions in labor rates or staffing that could substantially mitigate higher compliance costs.

Supply Markets. Magnesium is an abundant element and is primarily extracted from seawater and well and lake brines. The supply of these materials is extremely low-cost, and free in many cases (e.g., brines from the Great Salt Lake). For the affected facility, therefore, there is essentially no supply market that could be induced to share any incremental compliance cost burden.

Higher Prices. Because only one of the three domestic producers would be subject to compliance costs, higher prices would not be expected as a result of compliance. However, due to high capacity utilization, it is unlikely that producers would be able to increase supply if demand were to rise. Therefore, if demand for magnesium metals continues to increase, prices may rise somewhat. There is little foreign competition in this sector, so overseas supplies are unlikely to displace U.S.-made magnesium.

Evaluation of Cost/Economic Impacts

EPA believes that stringent regulation of magnesium process wastewater as a hazardous waste would not impose highly significant economic or financial impacts on Magcorp's facility in Rowley, Utah. Estimated Subtitle C compliance costs are moderate, though a large capital investment relative to current sustaining capital would be required. Because of the strength of the domestic facilities in the magnesium market and high current capacity utilization across the sector, EPA believes that facilities in the magnesium production industry might be able to increase prices somewhat without seriously undercutting sales. Furthermore, EPA's analysis suggests that Magcorp (the only facility that generates a special waste) could pass through a portion of any regulatory compliance costs to product consumers, because demand for and prices of magnesium have been strong in recent years, and are expected to remain so for the foreseeable future. Consequently, EPA believes that regulation of process wastewater from magnesium production by the anhydrous process under RCRA Subtitle C would not threaten the long-term profitability or economic viability of the Magcorp facility.

11.7 Summary

As discussed in Chapter 2, EPA developed a step-wise process for considering the information collected in response to the RCRA §8002(p) study factors. This process has enabled the Agency to condense the information presented in the previous six sections of this chapter into three basic categories. For each special waste, these categories address the following three major topics: (1) potential for and documented danger to human health and the environment; (2) the need for and desirability of additional regulation; and (3) the costs and impacts of potential Subtitle C regulation

Potential and Documented Danger to Human Health and the Environment

The intrinsic hazard of magnesium process wastewater is high to moderate as compared to the other mineral processing wastes studied in this report. Measurement of pH for two samples of the process wastewater indicate that the wastewater exhibits the hazardous waste characteristic of corrosivity, with a pH of approximately 1. However, magnesium process wastewater contains only two constituents that exceed one or more of the screening criteria used in this analysis by more than a factor of 10.

Despite the relatively high to moderate intrinsic hazard of this waste, current management practices and environmental conditions appear to limit the potential for the wastewater to threaten human health or the environment. Migration of contaminants from the wastewater pond has been observed, but the Utah Bureau of Water Pollution Control has stated that the seepage "was of low volume and did not pose a significant environmental or human health threat." This is partly because shallow ground water at the Rowley site is saline and unuseable (it is hydraulically connected with the Great Salt Lake), and partly because the pond is underlain by oolitic sand that may neutralize the low pH of the seepage. The pH of the seepage is being monitored under the conditions of a State permit that requires the seepage to be prevented if monitoring indicates that the pH is outside the acceptable range of 6.5 to 9. In addition, only a few constituents of the wastewater were present at concentrations that exceeded the screening criteria. Consequently, it is unlikely that releases from the impoundment would result in harmful contaminant concentrations in the Lake or underlying aquifers.

The finding that the potential for danger to human health and the environment is generally low is confirmed by the absence of documented cases of environmental damage. Releases of wastewater to the Great Salt Lake have occurred in the past when rising lake levels flooded the impoundment used for wastewater evaporation. The current impoundment, which was constructed to replace the flooded impoundment, has higher and thicker dikes to prevent flooding by the lake.

Likelihood That Existing Risks/Impacts Will Continue in the Absence of Subtitle C Regulation

While the relatively high to moderate intrinsic hazard of the wastewater is unlikely to change in the future, the waste management practices and environmental conditions that currently limit the potential for significant threats to human health and the environment are expected to continue to limit risks in the future in the absence of Subtitle C regulation. Despite the fact that this analysis is limited to the single site at which the waste is currently managed, EPA believes that the conclusion of low hazard can be extrapolated into the future because the environmental conditions in which the wastewater is managed are unlikely to change. Management of the process wastewater is unlikely to expand beyond the location studied for two reasons. First, the quantity of material involved makes it unlikely that the process wastewater would be managed off-site. Second, development of new facilities in substantially different environmental settings is unlikely because the Great Salt Lake provides the feedstock necessary for magnesium production by the anhydrous process.

The potential for increased risks in the future is further restricted by State regulation of the wastewater evaporation impoundment. Although the State of Utah excludes mineral processing wastes generated at the Rowley facility from hazardous waste regulation, the State has required that the facility maintain an NPDES no-discharge permit for its process wastewater surface impoundment and is tracking the seepage from the impoundment, as discussed above. The State recently enacted new ground-water protection legislation, and plans to consider the need for a ground-water discharge permit at the Rowley facility, though the effect of such permit requirements on the management of the surface impoundment is not clear.

Costs and Impacts of Subtitle C Regulation

Because EPA waste sampling data indicate that process wastewater from primary magnesium production by the anhydrous process exhibits the hazardous waste characteristic of corrosivity, the Agency has evaluated the costs and associated impacts of regulating this waste as a hazardous waste under RCRA Subtitle C. As with the other aspects of this study, the Agency's cost and impact analysis is limited in scope to the facility at Rowley, Utah.

Costs of regulatory compliance exceed $1.1 million annually under each of the three regulatory scenarios. Costs under the full Subtitle C, Subtitle C-Minus, and Subtitle D-Plus scenarios are almost identical, because adequately protective waste management unit design and operating standards are essentially the same under all three scenarios, given the nature of the waste and the environmental setting in which it is currently managed. EPA's economic impact analysis suggests that the operator of the potentially affected facility (Magcorp) could pass through a portion of any regulatory compliance costs that it might incur to product consumers, because demand for and prices of magnesium have been strong in recent years. Because the costs of Subtitle C regulatory compliance would not impose significant immediate impacts on the affected facility (less than one and a half percent of value added) and because the facility may have some ability to pass any such costs through to product consumers through higher prices, EPA does not believe that a decision to regulate process wastewater under Subtitle C would threaten the long-term profitability or viability of the Rowley facility.

Finally, EPA is not aware of any significant recycling or utilization initiatives that would be hampered by a change in the regulatory status of this waste. The process water is likely to be managed in much the same way as it is currently, with the exception that it would be treated prior to discharge to the existing surface impoundment. EPA does not believe that additional waste management requirements would materially influence the production processes employed at or general operation of the affected facility.

Exhibit 11-3
Compliance Cost Analysis Results for Management of Process Wastewater from Primary Magnesium Processing by the Anhydrous Process[(a)]

Facility	Baseline Waste Management Cost	Incremental Costs of Regulatory Compliance								
		Subtitle C			Subtitle C-Minus			Subtitle D-Plus		
	Annual Total ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)
Magcorp - Rowley, UT	368	1,231	1,918	286	1,183	1,668	249	1,183	1,668	249
Total:	368	1,231	1,918	286	1,183	1,668	249	1,183	1,668	249

(a) Values reported in this table are those computed by EPA's cost-estimating model, and are included for illustrative purposes. The data, assumptions, and computational methods underlying these values are such that EPA believes that the compliance cost estimates reported here are precise to two significant figures.